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VIRTUAL REALITY AT THE PC LEVEL

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## Introduction

The main objective of my research has been to incorporate virtual reality at the desktop level; i.e., create virtual reality software that can be run fairly inexpensively on standard PC's.

The standard language used for virtual reality on PC's is VRML (Virtual Reality Modeling Language). It is a new language so it is still undergoing a lot of changes. VRML 1.0 came out only a couple years ago and VRML 2.0 came out around last September. VRML is an interpreted language that is run by a web browser plug-in. It is fairly flexible in terms of allowing you to create different shapes and animations. Before this summer, I knew very little about virtual reality and I did not know VRML at all. I learned the VRML language by reading two books and experimenting on a PC.

## CAD to VRML

My first task was to translate existing NASA CAD drawings to VRML code. This would allow different NASA sites to create different components of a project using different CAD packages. The CAD files could then be converted to VRML and combined into one VRML document. Users could then view the objects using a free VRML browser. Users would then have the ability to easily check for compatibility between the different components.

In the next couple years, most of the CAD packages will probably be able to directly export to VRML format. Currently, most CAD packages require the use of a translator software package to convert their drawings to VRML. We were able to convert Intergraph's EMS and SolidEdge CAD drawings to VRML 2.0 by using the 3D/EYE's Trispectives translator. The Trispectives translator costs \$299 for the standard edition and \$999 for the professional edition. Support costs an additional \$500 per year. There are many other translators, such as Okino's PolyTrans, but I did not fully investigate them because that would have been too time-consuming and expensive. The new version of Parametric's ProEngineer CAD tool does have the capability to directly export to VRML 1.0. Most VRML browsers are able to handle both VRML 1.0 and VRML 2.0 files.

## VRML 1.0 to VRML 2.0

CAD packages and VRML 1.0 files allow you to create shapes, and the viewer can then choose to spin the objects, zoom in/out, etc. VRML 2.0 allows the designer to add programmable, interactive animation to the scene. That leads to a more appealing viewing experience and it can allow for more information to be disseminated. If you have an existing VRML 1.0 file, and you want to add animation to it, you need to convert the VRML 1.0 file to VRML 2.0 first, and then add VRML 2.0 animation commands. I found a free VRML 1.0 to 2.0 converter from SONY and checked it into the VRC library.

## VRML Authoring Tools

In addition to creating VRML files through the use of CAD packages, you can create VRML files by 1) directly entering VRML code into an ASCII text editor or 2) using a VRML authoring tool. It is very time-consuming and tedious to create an elaborate VRML world by directly entering VRML code into an ASCII text editor. Therefore, I recommend using a VRML authoring tool for elaborate VRML worlds. After using several trial version authoring tools, we purchased the VRealm Builder VRML authoring tool for \$495. It allows you to create rather complex VRML worlds fairly quickly.

I feel that is best to create elaborate shapes using the VRealm Builder tool, but it is best to create animation using native VRML code entered into an ASCII text editor. The VRealm Builder does provide the ability to add animation to VRML worlds, but it is rather cumbersome. Even if you use VRealm Builder to create the animation, you usually end up having to fine-tune and debug the resulting VRML code using an ASCII text editor. However, I expect that the animation capabilities of VRML authoring tools will improve in the future. VRealm provides one year of free technical support for any VRML questions.

## VRML Browsers

VRML browsers enable VRML worlds to be viewed. There are many VRML browsers. The two most popular ones are free – SGI's (Silicon Graphics's) Cosmo Player and InterVista's WorldView. They are both installed as plug-ins to the user's web browser. They both operate on Windows, UNIX, and MAC platforms, and with Netscape Navigator and Internet Explorer web browsers. They both render worlds fairly well, but they are not perfect. For example, if a "ViewPoint node" (a VRML object that describes where the viewer is positioned) is too close to another object, then the object is invisible to the viewer/user. Also, sphere and cylinder shapes do not appear smooth if the viewer is close to their edges. EMD's GView appears to be a slightly better VRML browser than Cosmo Player or WorldView, but it is not free – it costs \$69. GView includes a minimal VRML authoring tool. I primarily used Cosmo Player because I wanted to use what the VRC's customers would most likely be using. Cosmo Player is the most popular VRML browser because it is free and because Netscape has promoted and integrated it as its standard VRML browser. According to SGI, Cosmo Player version 2.0 is scheduled to "preview soon." I expect Cosmo Player and other VRML browsers to improve in the future. With the new browsers, VRML worlds will probably be able to load faster and render with greater clarity and smoother animation.

## VRML Embedded within HTML

VRML worlds can be embedded in HTML pages by using HTML page frames. Embedding VRML worlds in HTML pages can lead to more interesting and informative web pages. VRML and HTML frames can interact. Hyperlinks in either a VRML frame or an HTML frame can cause specified VRML or HTML files to be loaded into specified frames. The hyperlinks can also cause viewpoints to be changed within a VRML frame.

## Finding Virtual Reality Applications

I feel that one good way to find applications for virtual reality technology is to let people know about the technology so that it might spark ideas for its use in their current or future projects. The VRC may want to send e-mail out to NASA employees asking them to view the VRML models in the VRC library and the VRML models on the Mars PathFinder web pages. If they have questions or virtual reality project possibilities, then they could fill out an appropriate electronic form in the VRC. The VRC could periodically respond to the user requests.

## AXAF Project

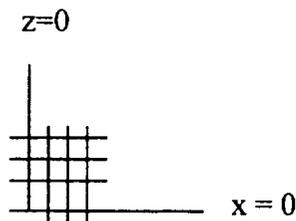
The project that I have spent the most time on is the creation of VRML code in order to display the AXAF telescope's view during its orbit. The idea for using VRML for the AXAF project came about due to NASA contractor Billy Wilson hearing about VRML's capabilities, and realizing that it would be a good fit for the AXAF project. Previously, AXAF project group members would visualize AXAF's orbit around the earth by looking at two stereoscopic images of the AXAF orbit and then crossing their eyes. This was a difficult task since the viewer's eyes need to be focused at a precise position behind the stereoscopic images.

The stereoscopic images were generated by an APL program written by Billy Wilson. In order to generate VRML images, Billy's program generates 3D coordinate points for the perimeters of the earth's land masses and for the AXAF orbit. The 3D coordinate points are passed into dll's (dynamic link libraries) that generate the corresponding VRML code. I wrote the dll's using C. Thus, the APL program generates a VRML file that contains the basic shapes needed for a 3D representation of the AXAF's orbit around the earth. I then added VRML animation code to the VRML file - the earth rotates and the user can press a button to start a virtual tour on the AXAF orbit. The tour changes the user's viewpoint so that the user sees what the AXAF telescope would see during its tour of the earth. Apparently, this is very helpful to the AXAF project members.

The AXAF VRML models were very favorably received by the AXAF project group leader, Leonard Howell. Leonard asked whether certain other features could be added to the VRML model. He asked 1) could we precisely coordinate the rotation of the earth with the revolutions of the AXAF orbit?, 2) could we add translucent radiation clouds above the earth? (the AXAF charter includes environmental issues such as radiation clouds), 3) could we turn off the user's headlight (by default, the current viewpoint emanates a forward directional light source called a headlight) and, instead, use light sources from the actual sun and moon positions? The answer to all these questions is yes (VRML is a powerful language!)

## VRML Generator Program

In addition to writing the C dll's as mentioned above, I wrote a complete program in C that generates VRML code for basic shapes. The program allows the user to create a new VRML file or append to an existing VRML file. It allows the user to create one or more of the following types of nodes – IndexedFaceSet, IndexedLineSet, ElevationGrid. I chose to handle these three node types because they are very useful building blocks for complex VRML worlds and because their syntax in native VRML code is not very user friendly. An IndexedFaceSet is a group of planar surfaces in 3D space such as the triangular surfaces that were used to form the earth's land mass shapes. An IndexedLineSet is a group of points in 3D space such as the ones used to form the AXAF's orbit line. An ElevationGrid is a contour map where heights (= y values) are specified at each intersecting x, z point. For the below grid, sixteen heights must be specified in left to right, top to bottom order:



Currently, the ElevationGrid function in the VRML generator program requires this very specific (and therefore limiting) input format. The ElevationGrid function can and should be enhanced so that it can handle any 3D coordinates entered in any order. The function should also be modified so that it automatically displays different heights with different colors (like a standard contour map).

The ElevationGrid function of my VRML generator program could be used to generate VRML representations of 3D spreadsheet applications. The ElevationGrid function could also be used to generate 3D displays for other applications that generate 3D coordinate values. NASA employee Carl Holden is working on a simulation of the thermal enclosure of protein crystal growth. He would like to be able to display his simulation output using 3D coordinate values. After talking to Billy Wilson about VRML, it occurred to Carl that he might be able to better represent his output values by taking advantage of VRML's capabilities. The VRML generator program could be used to create a VRML file for his output values.

### Web Communities

A web community consists of a group of users who regularly meet at a web site to discuss topics of common interest. A recent Business Week study found that the average visitation time for a standard web site is seven minutes, and the average visitation time for a web community site is thirty minutes. Thus, a web site's chances of making an impact on customers would tend to be greater if a web community is in place. 3D community web sites have been somewhat popular for the past several years. 3D communities allow each user to choose an avatar to represent himself/herself so that others may see him/her within the community world. Messages typically appear as cartoon bubbles appearing next to the speaker's avatar. The mouse and keypad arrows

are used to navigate within the world. The point of introducing 3D to web sites is to make the web site more appealing. However, 3D community companies have had limited success due to the cumbersome nature of moving around and communicating within the 3D worlds. The main problem appears to be that a user's limited forward viewpoint makes it difficult to quickly see the surroundings. 3D community companies such as WorldsInc and Oz have folded and others such as Blaxxun have scaled back their products considerably.

In searching for 3D web communities, I found ThePalace, a 2D web community product. ThePalace server software is much less expensive and much more popular than the 3D community server software. With ThePalace, it is very easy to move around and communicate within the worlds. ThePalace's most appealing feature is its auditorium capability. One or more speakers at various sites are able to speak while listeners at various sites are able to hear the speakers in real-time. Speakers can set up a slide show presentation and have the slides displayed in one of the auditorium web page's frames. Listeners are able to enter questions during a presentation. The questions are read by an auditorium moderator who decides which questions should be addressed by the speaker(s). I would expect the auditorium to be a valuable resource at NASA for conducting distance presentations and speeches.

On August 5, a representative from ThePalace visited the VRC and provided a demonstration of ThePalace product. We were favorably impressed. Their server software costs approximately \$2400 and their client software costs approximately \$600.

### Future Plans

I recommend that the VRC continues its pursuit of promoting and developing virtual reality at the PC level. ThePalace should be purchased and a server needs to be set up for it (ThePalace agreed to provide free telephone support to help set up the server). A developer should continue to work on the AXAF project. A more complete VRML AXAF world would be a good advertisement for attracting other virtual reality projects. Also, a more complete VRML AXAF world would be of great benefit to the AXAF project group. A developer should continue to work on the VRML generator program as it could be a useful utility for many VRML projects. The VRC might want to consider more advertising for its virtual reality tools so that NASA employees might contact the VRC with more project ideas. Without any advertising, we have already had several unsolicited suggestions for virtual reality projects, so there does appear to be a real practical need for virtual reality technology.

